The CSIRO Australian Water Availability Project team is pleased to announce the public release of

CSIRO AWAP Run 26c Historical Monthly and Annual Model Results for 1900-2009

Using improved Bureau of Meteorology AWAP Version 3 meteorological data

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South Eastern Australian Climate initiative

Australian Government
Bureau of Meteorology

These data replace the earlier AWAP 25a 1900-2007 historical series which used the Bureau of Meteorology (BoM) Version 1 meteorology.

What's new?

- Results have been updated to 2009, with 2010 to follow soon.
- Results are modelled with Bureau of Meteorology AWAP (BAWAP) V3 ***recalibrated*** rainfall (see below) and the best available temperature and solar radiation data, incorporating all additional stations, quality control, and algorithm improvements available to Nov 2010.
- Comprehensive spatial soil and vegetation information, including maps and data surfaces, are now available at www.csiro.au/awap/.
- New model products:
    - Relative soil moistures are now available in their original form (averaged over periods) and also as end-of-period instantaneous states for water balance calculations (Wrel1end, Wrel2end).
    - Open water evaporation (FWWater) is now calculated from a Penman-style formula.
- Bug fixes: Percentile ranks for solar radiation and potential evaporation were erroneous due to a post-processing software bug. They are now calculated correctly.
- Improved model initialisation: A more formal approach to the initialisation of soil moisture stores has been adopted. Run 26c is initialised using run-average soil moistures from a 110 year spin-up run using the same V3 meteorology.
- Data organisation at the ftp site: Each zip file now contains one year of data (12 monthly, 1 annual) for one model output or met variable. It is now easier to choose and download only the data you need.
- An updated README file (v5) is now available at the website www.csiro.au/awap/.

What's the same?

- The AWAP WaterDyn26 model is unchanged from the version described in the AWAP Phase 3 Final Report apart from the new calculation of instantaneous soil moisture and open water evaporation (see above).
- AWAP WaterDyn26 parameters (fixed and spatial) are unchanged from the previous version.

Your Questions Answered

1 What has changed with the meteorology?

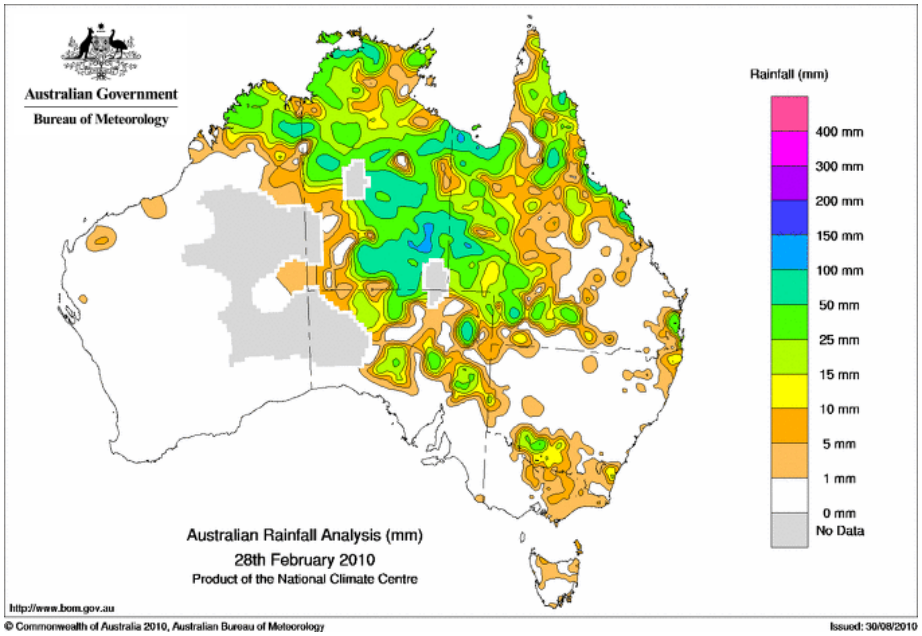
1.1 Recalibrated rainfall eliminates the discrepancy between summed-daily and monthly surfaces

The BoM National Climate Centre now produces two AWAP daily rainfall products, 'original' and 'recalibrated'. Both of these can be viewed at the BAWAP daily rainfall pages http://www.bom.gov.au/jsp/awap/rain/index.jsp. 'Recalibration' is a rescaling of the original daily surfaces to ensure that their sums match exactly the monthly surfaces created by reanalysis using monthly gauge totals (Jones et al. 2009). The discrepancy arises from the different length scales used to interpolate daily (80 km) and monthly (250 km) rainfall observations and differences in daily and monthly reports in real-time. Averaged over time (e.g. 30 years) the rescaling over most of the continent involves adjustments of up to ± 10% in rainfall totals. Recalibrated rainfall is considered the premium daily rainfall product, though differences are minor.

1.2 CSIRO replaces rainfall interpolation artefacts with simple disaggregated monthly rainfall

As part of the recalibration process, areas of interpolation failure in the most sparsely-gauged parts of the continent are removed by BoM and replaced with no-data values, shown as grey areas in the BoM recalibrated rainfall maps (see example below). The

no data regions are in effect areas where the network is insufficient to meaningfully define rainfall totals and rainfall gradient using existing methodologies.



For AWAP historical modelling, locations with one or more missing data values during a month are assigned the average daily rainfall calculated from the corresponding monthly reanalysis, which is gap-free. *This is done by the CSIRO AWAP team and is not included in BoM distributions of recalibrated rainfall.* This method of disaggregating monthly rainfall is simple, but does not produce obvious discontinuities in the monthly model results. Sparsely-gauged areas in the Central and Western Deserts are now relatively free of artefacts and transition smoothly to the rest of the continent. Of necessity, AWAP near-real-time operational modelling continues to use the 'original' rainfall surfaces because recalibrated rainfall is only available after the end of a month.

1.3 More rainfall data improves early record interpolations

More data are available to AWAP due to improvements in ADAM (Australian Data Archive for Meteorology), the source database for BoM's meteorological products. BAWAP interpolation is a topography-resolving scheme, requiring station altitudes. Prior to Version 3, a significant number of now-closed stations from the early part of the record were without published altitudes in the ADAM database (Jones et al. 2009). Where it could be done reliably (relatively flat areas) the altitudes of approximately 1000 of these stations (Fawcett 2010) were estimated using the GEODATA 9 Second Digital Elevation Model (Hutchinson et al. 2008, approximately 250 m grid resolution). Their rainfall data are now included in the BAWAP analyses.

1.4 Multi-day rainfall accumulation errors corrected

A number of multi-day accumulations (e.g. from gauges unattended on the weekend) were found to have been treated incorrectly in Version 1 due to a software error in the interpolation program, leading to some instances of double-counting. A comparison after removal of the accumulations showed that the noticeable effects were regionally constrained to areas of high rainfall coupled with high rainfall uncertainty

(particularly the Tasmanian Highlands) involving 1-2% of observations. The impact on mean rainfall was found to be regionally significant but less than 0.1 mm continentally. This problem was corrected and the data were reintroduced, superseding the notice of their removal in Jones et al. 2009.

1.5 Improvements to late-2007 rainfall and temperature data from completed quality control

Rainfall and temperature observations are subject to rolling 180-day (rainfall) and 90-day (temperature) quality control cycles. During this time the BAWAP surfaces are revised periodically to incorporate late arriving data and corrections (Jones et al. 2009). Changes tend to be more pronounced for the rainfall surfaces, as only one third of the gauge network reports in real time.

Run 25a was based on a bulk data distribution obtained from the BoM in February 2008. Consequently, model results for the last few months of 2007 (particularly November and December) were based on a less stable set of observations. Run 26c recalibrated rainfall and temperature data were downloaded well after the end of the normal quality control cycles.

1.6 Homogeneity of temperature interpolation improved between climate epochs

BAWAP uses anomaly interpolation methods. Climate averages for standard periods 1911-1940, 1941-1970, and 1971-2000 are used as the base surfaces to which temperature anomaly analyses are added (or multiplied in the case of rainfall). Changes to the observing networks between adjacent periods can cause locally large and spurious differences between climate averages for adjoining epochs. This is particularly an issue for temperature surfaces due to the smaller size of the measuring network compared with rainfall and also the lack of high elevation sites in the early years. Using stations with records in adjacent epochs, difference surfaces are constructed to allow the network in more recent periods to augment those of earlier periods. (See Jones et al. 2009 for a detailed description). The net result is the removal of spurious differences when Version 3 temperature data from earlier epochs (pre-1971) are compared with corresponding Version 1 data. The improvements are most marked in elevated regions and data sparse areas.

1.7 Improved temperature error detection methods implemented

A partial revision of daily temperature surfaces has been performed using automated bullseye detection and comparison against neighbouring stations to identify suspected wrong observations. These have been removed along with a list of previously-identified station errors from the base data which are input to the temperature analyses (Fawcett 2010).

1.8 Multi-day temperature accumulation errors corrected

A more consistent treatment of accumulated temperatures (from unattended stations) has been implemented to eliminate “numerous infelicities” in the daily grids associated with events such as the passage of a cold front during a weekend (Fawcett 2010). This reintroduction of multi-day temperature accumulations to the analyses supersedes the notice of their removal in Jones et al. 2009.

1.9 Changes to solar radiation data

For Run 26c, AWAP modelling uses solar radiation for 1990-2008 downloaded in bulk in May 2009, with a 2009 supplement obtained in March 2010. These data replace the February 2008 download used for the original Run 25a. Changes to the data in the period of 25a and 26c overlap (1990-2007) are not formally documented but reflect improvements occurring between Feb 2008 and May 2009.

To date BAWAP solar radiation data have not had a major revision but one is expected in 2011. Some changes have been introduced to the BoM processing algorithms but have not been applied retrospectively as yet. These include:

- Filling of inland water locations and the creation of a 10 cell coastal buffer by extrapolation, starting November 17, 2010. The satellite model used to derive the solar exposure is applicable only over land-filled grid cells. Extrapolation from the nearest land cell is provided as a convenience to eliminate gaps.
- Removal of occasional negative values of solar radiation occurring in cloudy or low radiation conditions as a result of bias removal combined with uncertainties in the satellite model. This involved a modification to the bias removal algorithm to rescale lower range values, and was implemented starting on January 1, 2007 (Grant, pers. comm. 18/7/2007).

Further improvements expected as part of the major revision include:

- Improving the daily integration algorithm to better handle days with missing hourly images, which will eliminate most occurrences of entirely missing days.
- Temporal interpolation (or filling with climatology) for the remaining days with no, or almost no, images.

For Run 26c we continue the current CSIRO AWAP conventions for dealing with these issues, using the updated data:

- Missing cells in daily BAWAP radiation files are filled with a monthly climatology created from QDNRM Silo meteorology (ground-based, Jeffreys et al. 2001) which includes a coastal buffer. These hybrid radiation files are used to create a monthly climatology to fill the 1900-1989 period.
- Negative values in the 1990-2006 data are not removed or modified.

When the major reprocessing of BoM AWAP solar radiation data is completed, we will perform a new historical run. At that point it will no longer be necessary to supplement the BAWAP data with Silo radiation for AWAP modelling.

Further information about BoM AWAP gridded daily solar exposure data can be obtained from the solar exposure metadata web page (http://www.bom.gov.au/climate/austmaps/metadata-daily-solar-exposure.shtml), the CAHMDA III extended abstract of Grant et al. 2008, or from Dr. Ian Grant at the Bureau of Meteorology.

1.10 Update to climatologies for CSIRO gap filling and percentile ranks

The BAWAP meteorology datasets do not include temperature data prior to 1911 or solar radiation prior to 1990. To allow AWAP WaterDyn modelling from 1900 (the start of the rainfall data) these periods are filled with synthetic daily series generated from monthly climatologies. These climatologies have been recalculated using the new Version 3 data: 1911 to 1940 to fill 1900-1910 daily temperatures; 1990 to 2008 to fill 1900-1989 daily solar radiation. Percentile ranks for all meteorology and model results are also calculated with respect to climatologies of the new data, or results modelled from the new data. These climatologies are for 1961-1990, or 1990-2008 for solar radiation and potential evaporation (which incorporates solar radiation).

1.11 Further information about the meteorology

For further information on BoM AWAP meteorology products please contact the Australian Bureau of Meteorology:

Dr. David Jones (rainfall, temperature, vapour pressure)
Dr. Robert Fawcett (rainfall, temperature, vapour pressure)
Dr. Ian Grant (solar radiation)

after consulting the following resources:

Jones DA, Wang W, Fawcett R (2009) High-quality spatial climate data-sets for Australia. *Australian Meteorological and Oceanographic Journal* **58**:233-248 (http://www.bom.gov.au/amm/docs/2009/jones_hres.pdf)

Grant I, Jones D, Wang W, Fawcett R, Barratt D (2008) Meteorological and remotely sensed datasets for hydrological modelling: A contribution to the Australian Water Availability Project. Proceedings of the Catchment-scale Hydrological Modelling & Data Assimilation (CAHMDA-3) International Workshop on Hydrological Prediction: Modelling, Observation and Data Assimilation. Melbourne, Jan 9-11, 2008.

Bureau of Meteorology AWAP web page: http://www.bom.gov.au/jsp/awap/

Please note that the Bureau of Meteorology's AWAP data archive is dynamic. Meteorology data downloaded directly from the BoM should always be cited with an access date.

Other references cited in this section:

Jeffrey SJ, Carter JO, Moodie KB, Beswick AR (2001) Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling & Software* **16**:309-330

Fawcett R (2010) CAWCR AWAP discussion points. Briefing notes for a meeting at the Bureau of Meteorology, 12 May 2010. Unpublished.

Hutchinson ML, Stein JA, Stein JL (2008) GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 3. Geoscience Australia.

2 Are the new model results significantly different…

2.1 Due to changes in the meteorology?

The new AWAP 26c model results reflect the many improvements in the latest Version 3 Bureau of Meteorology AWAP surfaces. We strongly recommend that researchers with a continuing interest in AWAP use the new model results. The Bureau of Meteorology considers Version 3 to be the first 'mature' release of the AWAP meteorology, with future releases expected to be more incremental in nature.

The significance of differences between the 25a and 26c model results will depend on the application, the region of interest, and the model quantities of interest, which are differently sensitive to changes in the met forcing. Except for sparsely gauged areas now being filled with disaggregated monthly rainfall, regional patterns are essentially unchanged. The new met data are different in their fine detail, however, and cursory analysis reveals slight changes in the strength of some regional trends.

2.2 Due to other factors?

Due to an oversight the original Run 25a was initialised using run-average soil moistures from a development version of the model which employed different model parameters and QDNRM Silo meteorology (prior to the availability of BAWAP). This means that Runs 25a and 26c start with significantly different initial soil moistures. Although the memory of the initialisation disappears relatively quickly in the upper layer, evidence of the differences in the lower layer appears to persist in some regions out to 1904. Since the true conditions at January 1, 1900 are unknown, we urge users to treat all model results in this early period with some caution.

3 How can I get the new data?

The new model results are available at:
ftp://ftp.eoc.csiro.au/pub/awap/Australia_historical/Run26c/

AWAP model results (excluding Bureau of Meteorology data) continue to be a research level product and are available for collaborative use with CSIRO AWAP team members. Where AWAP model data are to be used for significant scientific outputs (such as publications) we will wish to discuss co-authorship.

We are always interested to hear about new applications for AWAP data. Letting us know (even just a sentence or two) puts you on our user list, keeps you on our radar, and helps us in our battle to maintain and improve the AWAP system.

4 How should I refer to these data?

The new data can be referred to as the "CSIRO AWAP Run 26c Historical Model Results for 1900-2009" and cited as:

Raupach MR, Briggs PR, Haverd V, King EA, Paget M, Trudinger CM (2011) CSIRO AWAP Run 26c Historical Monthly and Annual Model Results for 1900-2009. Centre for Australian Weather and Climate Research (Bureau of Meteorology and CSIRO), Canberra, Australia. http://www.csiro.au/awap. Date of access.

Raupach MR, Briggs PR, Haverd V, King EA, Paget M, Trudinger CM (2009) Australian Water Availability Project (AWAP), CSIRO Marine and Atmospheric Research Component: Final Report for Phase 3. CAWCR Technical Report No. 013, Centre for Australian Weather and Climate Research (Bureau of Meteorology and CSIRO), Melbourne, Australia, 67 pp.

The report is available at www.csiro.au/awap.

5 When will 2010 be available?

We intend to make data for Jan 2010 to February 2011 available as quickly as possible after March 21, 2010.

6 What other improvements can we expect in the future?

6.1 NetCDF format

NetCDF versions of the 26c data will be announced shortly.

6.2 Dynamic meteorology updates and operational modelling

We are in the process of implementing dynamic data updates and modelling for the operational system (2007 to present, ongoing). The goal is to make the modelling system respond daily to any changes in the Bureau of Meteorology AWAP archive, so that the operational series will always provide results based on the best available meteorology data, rather than the 'bleeding edge' data available on the day after observation, as is currently the case. The operational series will employ original rainfall to the end of the current month (near-real time modelling) then use recalibrated rainfall as it becomes available. Ultimately we intend to eliminate the distinction between historical and operational modes, with the entire archive reflecting the best available data on the day.